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Agricultural Experiment Station
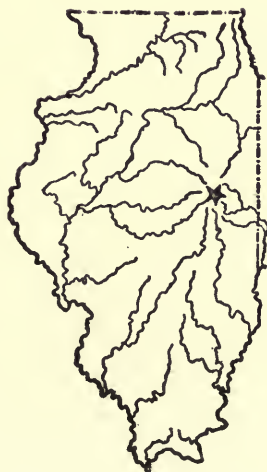
BULLETIN No. 251

BLOOMING PERIODS OF APPLES

By CHARLES S. CRANDALL

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Contents of Bulletin No. 251

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INTRODUCTION

The recording of periodical plant phenomena has received more attention in recent years than formerly, and there is now abundant evidence of general belief in the scientific and economic importance of data of this character.

Flowering of fruit plants in spring marks, perhaps, the most critical event in the production of a crop of fruit, and careful study of circumstances occurring at that time, together with an effort to determine and understand the influences that make for good or bad results, is deserving of attention, especially by those who make fruit growing a business. Owners or managers of orchards would derive satisfaction from annual records of flowering periods of the varieties they grow, and compilation of numerous such records would aid greatly in understanding the influences that cause wide variations from year to year, but the Experiment Stations may rightly be expected to maintain more complete and continuous records of blooming phenomena than is usually possible for individuals because, once started, the making of such records is regarded as a regular duty with its proper place in the schedule of operations, and is maintained regardless of changes in personnel. Many stations having fruit plantations now maintain such records and each succeeding year adds to their value. These records have been discussed in several valuable bulletins, and short accounts of work done or in progress have appeared in various station reports.

Blooming dates and periods are profoundly influenced by, in fact appear to be in large measure dependent upon, meteorological conditions, and, as these conditions vary extremely from year to year, long continued records are necessary in order to supply a sound basis from which to judge probable results under varying combinations of important influences. Any series of observations on plant events is of most value for the locality where made, but in many features is of value over wide districts, which possess somewhat similar soil and climatic features. Surface features of the country, as a whole, are so diverse, and the range of variation in all those elements that affect growth, flowering, and fruiting of plants is so wide that records should be kept at many different points by many observers. Out of the aggregate of such records valuable light on the causes of many phenomena now imperfectly understood, should eventually come.

The purpose of this publication is to give a brief account of flowering records for apples at the Illinois Station. The data to be considered include flowering dates and periods for 106 varieties having records ranging from ten to sixteen years: the list of varieties includes most of those commonly grown in the state, and also a considerable number of Russian varieties. The trees upon which observations were made were of nearly the same age, and were grown under identical conditions. Many varieties were represented by more than one tree, some by several trees, but the records to be mentioned are for single individuals of each variety.

CHARACTER OF RECORDS

Records have been taken on forms prepared in advance and bound in book form, one book for each year. Each page lists the trees of one row, numbered consecutively according to position, and is ruled in five columns with space allowed below for any remarks that seem desirable. The numbers occupy the left-hand column, followed by the three date columns: "opening of first flower," "full bloom," and "petals falling." In the fifth column is recorded a general estimate of the amount of bloom.

The record in the second column, except in rare instances, is a simple statement of fact; either a flower was open or was not open on a given date, but cases of receptive stigmas protruding before petals had expanded were sometimes encountered, and then the exact day of first open flower was a matter of question. This condition was so rare, however, with the varieties under consideration as to be negligible. In some of the crab-like species of the genus, notably in forms of *Malus floribunda*, *Malus toringo*, and *Malus microcarpa*, the maturity of stigmas was so commonly in advance of expansion of petals that the date of first open flower was often uncertain. Records of these crab-like species, however, are all below the ten-year limit and are not to be considered at this time.

Date of "full bloom" was often a matter of judgment and, hence, variable, especially in those seasons when flowers opened slowly because of storms and low temperatures. The third date, that of "petals falling," not infrequently was a matter of judgment and subject to fluctuation and error. Suppose that, following the opening of a few flowers, a change in weather suspended plant activities for three, four, or more days, this being followed by high temperatures and rapid opening of flowers. Under such circumstances the petals of the first flowers open would fall before the date of full bloom was reached. It was assumed that the date to be recorded should apply to the mass of flowers rather than to the few precocious individuals, but cases have occurred in which fixing a satisfactory date was difficult.

The rule, sometimes used, of placing the date for "petals falling" two days after full bloom may operate fairly well in some seasons, but in other seasons cannot be used; thus in 1907, and again in 1908, there were many instances in which the falling of petals was delayed four, five, or more days following full bloom.

In the fifth column is placed an estimate of the amount of bloom. Various systems of recording have been tried, including a decimal system with figures ranging from 0 to 1, but whatever is recorded is an estimate and fine distinctions are of no advantage. The plan now in use recognizes five grades; namely, no bloom, scant bloom, moderate bloom, full bloom, and very full bloom, or as being more quickly recorded 0, 1, 2, 3, and 4. These distinctions serve every purpose. Unusual features exhibited by individuals have been separately recorded.

The ideal plan for recording flowering or any other phenomena of plant life is for one individual to do the work in each and all years of the series, but this is rarely possible. Seven men share the responsibility of the nineteen years of phenological records at this station; for the sixteen years to be considered the field records were made by six men: one made the record for five consecutive years, one for four years, one for three years, one for two years, and two made each the record of one year. An assistant has done the work for the last five years, another assistant was in charge for the first two years; for the intervening years the work was done by senior or graduate students under direction. Every effort was made to secure as accurate a record as possible. Beginning before any flowers were open, each tree was visited daily thruout the period of bloom, and during times of high temperatures two and in some cases three visits were made each day.

FLOWERING PERIOD VARIABLE

For central Illinois the flowering period for apples is short; in some seasons very short. In some years heat waves occur that bring trees into full bloom with astonishing rapidity. Flowers thus suddenly opened retain the ability to function for a very short time and the whole flowering process is over almost before it is realized that blooming time has come. On the other hand the spring season, in certain years, has been characterized by abnormally low temperatures, by excessive rainfall, or by rapidly alternating periods of heat and cold, so that flowering of trees has been very irregular and the season much prolonged.

Presumably, the heat waves occurring in this region are more intense, and hence more effective in pushing buds than in regions farther north, and are less intense and less effective than in regions farther south. However, comparisons of the length of flowering periods for different regions cannot be safely based upon latitude alone, because such local features as altitude, slope, soil, exposure to air currents, and

proximity to bodies of water or belts of timber may be responsible for wide variations.

BLOOM RECORDS OF OTHER LOCALITIES

Before entering upon detailed consideration of the bloom records of this station, and for convenience of comparisons between dates and periods here and elsewhere, brief mention may be made of a few of the more important records published.

Virginia.—In 1905 Price[1] of the Virginia Experiment Station, gave blooming periods for 137 varieties of apples, including thirteen crab varieties. The observations cover periods ranging from two to thirteen years, but for about 64 percent of the varieties the observations extend over nine or more years.

For each variety, the blooming period begins with the opening of the first flower and ends two days after full bloom. The earliest commencing date of bloom is April 21, the latest commencing date, May 5. The earliest ending date is April 28, the latest, May 12. Aside from the crabs, which, with the exception of Soulard, are among the earliest to bloom, there are but eight of the late-blooming varieties the periods of which do not, in some degree, overlap the periods of varieties blooming earlier. Considering all varieties, the flowering period—from the opening of the first flower on the earliest blooming variety, to the end of the period for the latest blooming variety—extends from April 21 to May 12, or twenty-two days. Individual periods range from five days, as the average of nine years for Red June, to eleven days as the average of three years for Seedless; 3 varieties have six-day periods, 38 varieties have nine-day periods, and 5 varieties have ten-day periods. The average period for all varieties is 8.14 days.

The latitude of the Virginia Station is 37° 15′; the elevation 2,170 feet above sea level. A summary of meteorological records for the twelve-year period 1893-1904 gives the mean annual temperature as 51.5°; mean maximum, 63.22°; mean minimum, 40.04°; the absolute maximum, 96°; and the absolute minimum, –13°. Mean annual precipitation, 39.41 inches.

New York.—Flowering periods for a more extended list of varieties, 278 in number, were given in March, 1908, by Hedrick[2] of the Geneva, New York, Station. Here the years of observation ranged from three to six, with a little more than one-third of the varieties included under the longer period.

The full flowering period extends from May 10 to May 29, or twenty days; two days less than the corresponding period in Virginia, but the earliest flowering date in New York precedes the ending

[1] H. L. Price, Va. Agr. Exp. Sta. Bul. 155.
[2] U. P. Hedrick, N. Y. Agr. Exp. Sta. Bul. 299

date of the period for the latest flowering variety in Virginia by only two days. Varietal periods range from six days for each of 2 varieties (Avery and Winter Citron), and seven days for 11 varieties to twelve days for each of 5 varieties. Those varieties having average blooming periods of ten days or more number 121 (or 43.52 percent of the whole number). The average period for all varieties is 9.35 days.

In a later publication, Bulletin 407, issued in May, 1915, Hedrick gives blooming records for 348 varieties for the five-year period 1910-1914. About one-half of the varieties in this list appeared also in the earlier list. In this bulletin, blooming periods for individual varieties are not given, but the varieties are classified to show their relation to each other as to earliness or lateness; they summarize as follows:

	Number	Percent
Very early	10	2.87
Early	55	15.81
Midseason	239	68.68
Late	34	9.77
Very late	10	2.87

Of the blooming season Hedrick says, "The blooming season of apples at this Station averages twelve days. The shortest season of bloom was seven days in 1913 and the longest season, eighteen days in 1910. The first date of bloom for apples in 1912, an average year, was May seventh."

The latitude of the New York Station, as given in Bulletin 299, is 42° 53′; and the altitude, 525 feet above sea level. The Station is, therefore, 5° 38′ farther north, and has an altitude less by 1,645 feet than that of the Virginia Station. From these differences in latitude and altitude considerable differences in flowering time of apples should be expected. But often there are local conditions of soil or climate that have modifying influences as important as those of latitude and altitude, and, from available data it does not seem possible to specify the factors accountable for an average full flowering period two days longer and an average individual variety period 1.21 days shorter in Virginia than in New York.

The mean annual temperature at the New York Station, as given in the report for 1917, ranged from 43.3°, in 1885, to 49.7° in 1913. The average for the thirty-five year period is 47.4°. For the month of May the mean for the thirty-five years is 56.5°, with the highest mean, 64.09°, occurring in 1911, and the lowest mean, 51.3°, in 1907. Annual rainfall has varied in the thirty-five years between 19.35 inches in 1899 and 38.69 inches in 1903; the average for the period is 27.49 inches.

Oregon.—Lewis and Vincent[1] of the Oregon Station gave blooming records for ninety-five varieties of apples for the two years 1907 and 1908, with diagrams showing length of time in bloom for each variety. The earliest commencing date is April 5 for Transcendent Crab, the latest commencing date April 23 for Baldwin; the earliest date for petals falling is April 15 for Transcendent Crab; the latest for petals falling is May 2, and this date applies to eight varieties; namely, Holland Peppin, Jonathan, Missouri Pippin, Yellow Newtown, Rome, Walbridge, Winesap, and York Imperial.

The days intervening between the earliest and latest beginning dates number nineteen, and between the earliest and latest ending dates, eighteen. The full flowering period April 5 to May 2 is twenty-eight days. For individual varieties, the periods range from seven days each for Martha Crab and Melon to fifteen days each for Tetofsky and Whitney. Varieties having blooming periods ten or more days in length number 78, or 82.1 percent of the total number; the mean length of period for all varieties is 11.31 days. Comparing this mean of 11.31 days for all varieties for all years with the mean of 7.17 days as found at the Illinois Station, it appears that the average flowering period in Oregon is longer by more than 50 percent than in Illinois. Varieties in the lists of the two stations are for the most part different, there being only fourteen that appear in both lists, but, whether comparison is made between these fourteen varieties at the two stations or between the entire lists, the difference in length of period remains the same. As the Oregon record here considered covers but two years, range of variation of periods in different years does not appear, but in Bulletin 82 of November, 1904, Lake refers to variation in blooming as follows: ''A very variable relation exists from year to year not only between different varieties, but between the various phases of development in the same variety, for example; in 1896 Delaware Red and Domine were in full bloom seventeen days apart, but in 1897 they were in full blossom only two days apart.'' Further regarding Fameuse he says, ''The period from the opening of first blossoms to the time when the tree is in full blossoms may vary from year to year from three to fourteen days.''

England.—Going outside our own country, there are available certain English records of apple blooming periods that may be mentioned briefly. Blooming periods for apples in England, in general, are longer than in this country and it does not appear that they are subject to those extreme fluctuations in duration of periods in different years that characterize records at many points in this country. Mean temperatures in England are lower than at the Illinois Station; the

[1]C. I. Lewis and C. C. Vincent, Ore. Agr. Exp. Sta. Bul. 104.

daily range is less, and the hot waves that are accountable for the extremely short blooming periods often experienced here appear to be wanting.

Of English blooming periods Director F. J. Chittenden[1] of the Horticultural Research Laboratory at Wisley in Surry says, ''The time of flowering of apples varies between rather wide limits, both as to the commencement and as to the period over which the flowering continues. It commences in southeast England about the third week in April in early years and continues into the second week in June in late years. During the four years 1908-1911, in which records have been kept at Wisley, our earliest apple to open, Red Astrachan, was in full bloom in 1910 on April 21; in 1911, May 2; in 1909, May 3; and in 1908, May 7; while the most consistently late-flowering variety, 'Royal Jubilee,' was in full flower in 1908 on May 23; in 1909, May 17; in 1910, May 20, and in 1911, May 19.'' ''The period during which one variety or other of apple was in full flower (ignoring the few days, about seven or eight, before, and the few, about eight or nine, after full flowering time, during which some flowers were open) was, in 1908, eighteen days (May 6 to May 23); in 1909, twenty days (May 3 to May 22); in 1910, thirty-five days (April 21 to May 25); and in 1911, eighteen days (May 2 to May 19).''

The same irregularities that characterize blooming records in Illinois are found, also, in the English records; that is to say, blooming times and periods of varieties are not constant, they do not maintain a definite order of blooming, nor can they be depended upon to flower at a time having a definite relation to the flowering of other varieties. The author quoted above arranges the blooming record of 168 varieties in order from earliest to latest, and says of this arrangement: ''It is to be clearly understood that this 'average order of flowering' represents only approximately what is likely to happen in any particular year, but it is believed that it is sufficiently accurate to serve as a guide as to what varieties are most likely to be in flower at the same time. One might choose any of a dozen above or below any particular variety for planting with it to furnish pollen with the certainty that any one of those varieties would sufficiently approximate its full-flowering period to the one chosen.''

In a paper read before the Royal Horticultural Society[2] entitled ''Observations on the Blossoming of Our Hardy Cultivated Fruits,'' Mr. Cecil H. Hooper gives a table showing average blooming periods for the years 1908, 1909, and 1910 of 33 varieties of apples at Wye, Kent, England. These average periods range from 12.66 days to 22 days; the average number of days in flower is 17.66. Each period

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[1] Jour. Roy. Hort. Soc. 37 (1911-12) pp. 352-355.

[2] Jour. Roy. Hort. Soc. 36 (1910-1911) pp. 548-564.

begins with the opening of the first flowers and ends when nearly all petals have fallen. The full period for all varieties extends from May 1 to June 9, or forty days. The number of days between opening of the first flower and full bloom ranges for the varieties listed, from four to ten, with an average of 7.42 days, and between full bloom and completion of bloom from six to sixteen, with an average of 10.33 days. "In individual flowers the length of time from opening to fall of petals is about seven days."

BLOOM RECORDS AT THE ILLINOIS STATION

Detailed consideration of blooming periods at the Illinois Station may now be given. These records cover the years 1901 to 1916 inclusive, and include 106 varieties. Of these varieties 38 are recorded as having bloomed in each of the sixteen years; 24 varieties bloomed in each of fifteen years; 23 in each of fourteen years; 11 in each of thirteen years; 5 in each of twelve years; 3 in each of eleven years; and 2 in each of ten years.

Six other varieties of the older plantation have records of bloom for numbers of years less than ten, but these are omitted, as are also the records for trees planted in 1907 and 1908 and which now have records extending from one to five years.

For the sixteen years, 1901 to 1916, the flowering periods ranged from ten days to twenty-two days; the average was approximately sixteen days. Records of two years, 1906 and 1911, approximate the average; seven years had periods one to six days longer than the average, and seven years had periods from one to six days shorter than the average.

Full Flowering Periods for All Varieties

By the term "full flowering period" is meant the period of time, in days, between the first opening of a flower on the earliest blooming variety and the falling of petals from flowers of the latest blooming variety.

The earliest date recorded for commencement of bloom was April 2 in 1910, the latest date in the column "petals falling" was May 21, 1904. The extremes, then, are fifty days apart and the median date would fall between April 26 and April 27. But there is here included one year so abnormal as to stand entirely apart from all other years. Reference is made to the year 1910, in which the first flowers opened April 2 and petals of the latest flowering variety began falling April 19, one day later than the earliest opening of flowers in any other year. If 1910 were omitted the full flowering period for all varieties

TABLE 1.—FULL FLOWERING PERIODS OF 106 VARIETIES FOR YEARS 1901-1916

Year	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916
Earliest beginning date	5-1	4-28	4-18	5-5	4-19	4-26	4-20	4-19	4-29	4-2	4-28	4-26	4-23	4-27	4-23	4-29
Latest ending date	5-10	5-9	5-8	5-21	5-7	5-11	5-11	5-9	5-16	4-19	5-13	5-9	5-7	5-11	5-2	5-11
Full flowering period, *days*	10	12	21	17	19	16	22	21	18	18	16	14	15	15	10	13

DIAGRAM OF FLOWERING PERIODS

April | May

Year 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 | 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

1901 18
1902 ....
1903 21
1904 17
1905 19
1906 ....
1907 .... 22 ... 21
1908 ....
1909 18
1910 .... 18 ... 10 ... 12 ... 16
1911 16
1912 14
1913 15
1914 .... 15 ... 10
1915 ....
1916 13

for fifteen years would extend from April 18 to May 21 or thirty-four days.

The accompanying diagram shows graphically the length of the flowering period for each year and the relation, as to length of period, of one year with another. Only in the year 1906 did all of the 106 varieties bloom. For the other years the numbers of varieties blooming ranged from 76 in 1901, to 103 in 1904, 1911, and 1912, 104 in 1905, and 105 in 1910. The average number of varieties flowering each year falls between 96 and 97.

EARLY BLOOMING VARIETIES

Dates of opening of first flowers on earliest blooming varieties ranged from April 2 in 1910 to May 5 in 1904, a difference of thirty-four days. The average date for the sixteen years was April 24. In nine of the sixteen years this date of first open flower was later than the average and in the other seven years it was earlier.

Numbers of varieties opening flowers on the first day of bloom, in the different years, vary between 1 and 46. The average was between 8 and 9 (8.68).

In 1907 Early Ripe opened the first flower April 20 and was the only variety recorded as having open flowers on that date; it was followed by 7 varieties on April 21, 15 on April 22, 2 on April 23, 15 on April 24, 2 on April 25, 22 on April 26, 7 on April 27, 1 on April 29, 2 on April 30, 4 on May 1, and 4 on May 2, so that for this year the varieties, in the opening of first flowers, were spread over thirteen days and opened flowers on twelve of these days. Early Ripe is a fairly consistent early bloomer; it appeared on the first day of bloom in eight of the fifteen years for which it has record; it appeared on the second day in 1912, in which year it was preceded by two varieties; it opened flowers on the third day in each of four years— in 1901, with 17 varieties one day in advance of it; in 1902, with 15 varieties one day in advance; in 1903, with 7 varieties leading; and in 1906, with 8 varieties in advance. In 1911, it opened its first flower on May 2 in company with 17 other varieties, while 44 varieties were from one to four days in advance of it. Most varieties exhibited wider fluctuations in regard to relative position on first bloom than did Early Ripe.

The only variety that showed greater tendency to constancy of position in relation to flowering of other varieties was the Russian variety, Zuzoff, which appeared in the lists of first blooming varieties in eleven of its sixteen years of record. For the other five years this variety appeared on the second day of bloom in each year and had from 1 to 13 other varieties one day in advance in opening blossoms.

Oldenburg, which is one of 7 varieties having May 1 as the earliest date of open flowers in 1901, one of 9 having April 28 as the earliest

bloom date in 1902 and appearing in similar groups in three other
years, was one of 22 varieties to open the first flowers on April 24 in
1903.   This was the seventh day of bloom and 35 varieties were
recorded as having open flowers on one or other of the six preceding
days.   In 1905 Oldenburg did not open flowers until the eighth day
of bloom.   It was one of 15 varieties opening the first flowers on April
26 while there were 5 varieties with open flowers on April 19, and
65 with open flowers on dates between April 19 and April 26.   For
the year 1905 there were 104 varieties blooming and of these 70, or
67.3 percent, had earlier dates of first open flowers than did Olden-
burg.   In seven other years varying numbers of varieties had open
flowers earlier by one to five days than did Oldenburg.

Other varieties show the same erratic shifting of relative flowering
dates from year to year; some with more radical changes than others,
but all showing that varietal flowering dates are in no sense fixed, but
vary within wide limits.

Causes for varietal fluctuations in relative dates of first open
flowers must be looked for in individual differences in the vigor of
the trees.   All trees are subjected to the same wind, moisture, and
temperature conditions, and presumably the soil is uniform, but all
do not behave in the same manner with reference to any of their
functions; one tree, in a given year, makes greater growth than
another, has more and better foliage, and exceeds its neighbor in fruit
production; in another year the performance of the two may be
exactly reversed in all these particulars.

In the same way response of flower buds to the stimulus of advanc-
ing spring may be quick and vigorous or tardy and weak depending
upon the condition of the individual.

LATE BLOOMING VARIETIES

While some varieties have a general tendency to bloom early,
others exhibit the opposite tendency, but no variety in either group
holds a particular position in relation to other varieties with reference
to constancy.   The period over which the opening of first flowers
extends is extremely variable from year to year and its length is gov-
erned largely by temperatures.   A continued warm wave will group
all varieties within a short period, as was the case in 1915, when the
period from the opening of first flowers on the earliest blooming
variety to the opening of flowers on the latest blooming variety was
only five days.   Intervention of lower temperatures, on the other
hand, will greatly extend the period.   Thus in 1905 there were seven-
teen days between opening of first flowers on earliest and latest varie-
ties.   For the other fourteen years this period varies between eight
and fourteen days, with an average for all years of a fraction over
ten days.

The varieties that most consistently held the position of latest bloomers were Wythe and the Russian variety, Repka Malenka. Wythe occupied the position of latest bloomer, alone in 1905 and 1908, in company with Repka Malenka in 1911, in company with Repka Malenka and Hall's No. 3 in 1910, in company with 3 other varieties in 1903 and 1913, and with 4 others in 1906 and 1915. Thus of the twelve years in which Wythe bloomed it had the latest date of first open flowers in eight years. For the other four years Wythe, in 1902 had the same date of first bloom as 15 other varieties; it was earlier by one day than 4 varieties, and earlier by three days than Repka Malenka. In 1904 Wythe stood alone with first bloom on May 11, but was two days earlier than Sandy Glass. In 1912 Wythe had first bloom on May 3, in company with 8 other varieties, and was one day in advance of Repka Malenka, Garfield, and Hall's No. 3. For 1916 Wythe had the same date of first bloom as 11 other varieties, bloomed one day earlier than 13 other varieties and two days earlier than Repka Malenka.

Repka Malenka had the latest date of first open flower in ten of the fourteen years in which it flowered; it occupied this position alone in 1902 and 1916, and was accompanied by Wythe or from 1 to 4 other varieties in the other eight years. In 1905 Repka Malenka was four days, and in 1908 two days earlier than Wythe; in 1904 it was four days earlier, and in 1914 three days earlier than the latest flowering varieties.

Other varieties that have had place among latest bloomers are Hall's No. 3 in 1906, 1909, 1910, 1912, 1913, and 1915; Rome in 1906, 1909, 1913, and 1915; Grimes in 1903; Willow in 1913; Huntsman in 1914; Tolman in 1903; and about a dozen other little-known varieties, mostly Russian.

As before stated, no variety has proved constant in its flowering position as related to other varieties, but perhaps there is less shifting of dates and positions among the late flowering than among the very early flowering varieties.

BLOOMING PERIOD OF 1910

For the year 1910 the seasonal abnormality of bloom was so great that attending circumstances deserve mention in some detail. As stated, the first open flowers appeared April 2 and petals were falling from the latest blooming variety on April 19, a period of eighteen days. A period of the same length was recorded for 1909, one a day shorter in 1904, and another a day longer in 1905. Nine of the remaining twelve years had periods from two to eight days shorter and for three years the periods were three and four days longer.

The varieties commencing bloom on April 2 were Early Ripe and Zuzoff; these were followed April 3 by open flowers on 9 varieties;

namely, Borovinka, Borsdorf, Hargrove, Isham, Osimoe, Ostrakoff, Red Anis, Red Stripe, and Yellow Siberian Crab. First bloom appeared on 11 varieties April 4, on 20 varieties April 5, on 8 varieties April 6, on 16 varieties April 7, on 12 varieties April 8, on 19 varieties April 9, on Garfield, Grandmother, Ox Sweet, Roe's Tolman, and Rome on April 11, and on Hall's No. 3, Repka Malenka, and Wythe on April 12.

The varieties flowering number 105 covering the full list with the exception of Bogdanoff. Of the two varieties opening flowers April 2, Zuzoff completed its period, that is the petals were falling, on April 9, and April 10 is the date recorded for falling petals of Early Ripe. The last variety to reach the stage of falling petals was Repka Malenka on April 19, and of the two varieties having the same beginning date, April 12, Wythe reached the end of its flowering period April 17, and Hall's No. 3 on April 18.

Individual periods for the 105 varieties that bloomed ranged in length from four to nine days, divided as follows:

Periods of
—four days . . . . 7 varieties
—five days . . . . .11 varieties
—six days . . . . .29 varieties
—seven days . . . . .23 varieties
—eight days . . . . .22 varieties
—nine days . . . . .13 varieties

These individual flowering periods were not affected by the abnormal earliness of bloom; they ranged much the same as in normal years. It appears that the whole flowering period was simply moved forward until the end of bloom, for the latest flowering variety and the earliest opening of flowers in any other year overlap by only one day.

The earliness of bloom is directly attributable to the abnormal meteorological conditions that prevailed during March. This month was dry; rain fell on only four days, the 18th, 19th, 26th, and 30th, with an aggregate precipitation of only .38 inch. The first two days of the month were recorded as cloudy; of the days following, eighteen were partly cloudy and eleven clear. The mean daily temperature for the month was 52.3°, 12° above normal; the mean minimum, 37.7°; and the mean maximum, 63°. The last frost of the month occurred on the morning of March 21, and there were early morning frosts on thirteen of the preceding days.

For the last fifteen days of the month the mean temperature was 58.4°; the mean maximum, 73.9°; and the mean minimum, 44.7°. The absolute maximum was 85° on March 24. There were four days

on which the maximum was above 80° and ten days on which it was above 70°.

For the eighteen-day period of bloom, April 2 to 19, rain aggregating .82 inch fell on eight days; the last three days were cloudy, eleven days were partly cloudy, and four days were clear. The mean daily temperature was 53.4°; the mean maximum, 65.6°; and the mean minimum, 42.1°.

The mean daily temperature for the flowering period was from 1.4° to 5.3° lower in three years, namely 1904, 1907, and 1908, and from 2.2° to 13.7° higher in the twelve other years.

COMPARISON OF THE PERIODS FOR THE YEARS 1904 AND 1910

Having given the temperatures for the month preceding and for the period of bloom of the year 1910 in which blooming was abnormally early, it will be of interest to make comparison with the blooming period for 1904, in which year the blooming period was the latest of those recorded. In 1904 there were 103 varieties blooming, two less than in 1910.

Three varieties flowered in 1910 that did not flower in 1904, and one variety flowered in 1904 that did not flower in 1910. Eliminating these four varieties limits the comparison of the two years to 102 varieties that have records for both years. The full flowering periods for the two years differ by but one day; seventeen days in 1904, and eighteen days in 1910, but the beginning date in 1910 was thirty-four days in advance of the beginning date in 1904. The two dates were April 2 in 1910 and May 5 in 1904. As the periods differ in length by one day the ending dates, April 19 in 1910 and May 21 in 1904, are separated by thirty-three days.

Flowering periods for individual varieties tended to concentration about the six-, seven-, and eight-day periods in both years; in 1904, 77 or 75.49 percent of the varieties fell under these three periods and in 1910, 71 or 69.60 percent of the varieties were recorded as in these periods.

The day-groups in 1904 numbered eight, with a range of four to fourteen days; in 1910 there were six day-groups with a range of four to nine days. In 1904 there were two varieties having ten-day periods and one with a fourteen-day period. Distribution of varieties into periods differing in length by one day was as follows:

Varieties having each a period of

	1904	1910
—four days	3	7
—five days	6	11
—six days	16	27
—seven days	28	22
—eight days	33	22
—nine days	13	13
—ten days	2	0
—eleven days	0	0
—twelve days	0	0
—thirteen days	0	0
—fourteen days	1	0
	102	102

The average period was 7.34 days for 1904 and 6.78 days for 1910; longer by .56 day in the year when the blooming period occurred thirty-four calendar days later than in the year of early bloom. It would be reasonable to expect that in contrasting the blooming periods of two years, one of which was more than a month later in the season than the other, the periods of individual varieties would be shorter and concentrated under fewer day-periods in that year in which the blooming time was latest in season. This is expected because the more powerful action of the sun and the presumed greater aggregate of heat units in the advanced season should so stimulate plant functions that blooming of varieties would proceed rapidly and result in concentration within narrow time limits of short individual periods. In this case, however, the reverse was true. Not only were the full flowering periods, altho separated by more than a month, of nearly equal length, but individual periods had a shorter average length in the early year and there were twice as many varieties having four- and five-day periods as in the later year.

Temperatures preceding and during the blooming period of 1904 may now be examined, considering first a period of thirty-two days from April 3 to May 4, which equals the period March 1 to April 2 considered in relation to the bloom in 1910. For this period the maximum temperature was 80°; minimum, 22°; and mean, 46.60°. Differences between the temperatures for the two years are most readily compared by placing them in parallel columns as below.

1904	*Maximum*	*Minimum*	*Mean*
April 3–May 4	Absolute 80°	Absolute 22°	46.60°
	Mean 57.97°	Mean 35.84°	
1910			
March 1–April 1	Absolute 85°	Absolute 17°	52.30°
	Mean 63°	Mean 37.7°	

The absolute maximum for the early period of 1910 was 5° higher than for the later period of 1904 and this difference holds approximately for the mean maxima of the two periods.

The absolute minimum for 1910 was 5° lower than for 1904, but the average of minimum temperatures for the periods under consid-

eration (for the two years) was nearly 2° higher for 1910 than for 1904. Mean temperatures for the periods were 46.60° for 1904, and 52.30° for 1910; the mean for the year of early bloom 5.7° higher than for the year of late bloom.

Comparing actual blooming periods—April 2 to 19 in 1910, and May 5 to 21 in 1904—it is found that higher temperatures prevailed in 1904 than in 1910. The maximum in 1904 was 84°, in 1910, 80°, with an average maximum in 1904 of 70.05° and in 1910 of 65.6°; the 1904 average was 4.45° higher than in 1910. Minimum temperatures were 41° for 1904 and 30° for 1910; the average minimum, 48° for 1904 and 42.1° in 1910; the 1904 average was nearly 6° higher than the average of 1910. Mean daily temperatures were 58.91° for 1904 and 53.4° for 1910; that for the year of late bloom was 5.51° higher than that for the year of early bloom.

For the thirty-two days preceding bloom in 1904, temperatures of 32° or lower were recorded on twelve days; for the similar period in 1910, on ten days. During the blooming period in 1904 there were no frosts, but in 1910 frosts occurred on five days.

From this examination of temperatures, it appears that the heat stimulus for the period of thirty-two days preceding the first opening of flowers was somewhat greater from March 1 to April 1 in 1910 than it was from April 3 to May 4 in 1904, and that for the periods of bloom there were higher temperatures for the May period of 1904 than for the April period of 1910.

The chief reason for the unseasonable advance of flower buds in 1910 appears to rest in the high temperatures that prevailed during the period of thirty-two days just preceding the opening of flowers. The temperatures thruout the period of blooming continued sufficiently high to concentrate varietal periods into six groups of four to nine days, with a shorter average individual period than is recorded for 1904, when the bloom came a full month later in the season.

To what extent differences in moisture supplemented the temperature differences between the two seasons compared is not known, but it seems probable from differences in precipitation that the influence may have been important. For the thirty-two-day periods preceding bloom in the two years the rainfall and cloudiness are recorded as follows:

	Rainfall (inches)	No. of days on which rain fell	Clear days	Partly cloudy days	Cloudy days
1904	3.44	7	10	18	4
1910	.38	4	12	18	2

Rainfall for the 1904 period was nine times that of the 1910 period. Clear days were two less and cloudy days two more than in 1910. The heaviest rainfall of 1910 was less than the least fall in 1904 and the heaviest single rain (1.61 inches) in 1904 was more than four times the total for the period in 1910.

For the seventeen-day duration of bloom in 1904, the rainfall was .94 inch, distributed over nine days, two of which record only a trace. In 1910 the rainfall for the eighteen-day period of bloom was .82 inch, distributed over ten days, and again two of the days record a trace only. Five of the seventeen days in 1904 and four of the eighteen days in 1910 were clear. Eleven days of the periods in each of the two years were partly cloudy; one in 1904 and three in 1910 were entirely cloudy.

After blooming began, varieties responded much more rapidly in 1904 than they did in 1910. This is shown by the fact that only two varieties opened flowers on the earliest date of bloom in 1910 and at the end of the fifth day from the beginning of bloom only 50, or 47.6 percent of all varieties had open flowers; whereas in 1904 there were thirteen varieties that opened flowers on the first day of bloom and at the end of the fifth day 99, or 96.11 percent were recorded as having open flowers.

Comparing flowering periods for individual varieties, it appears that 23 varieties had periods of equal length in the two years, while for 79 varieties the periods were either longer or shorter in one year than in the other. Thus 19 varieties had periods one day longer in 1904 than in 1910, and 13 varieties had periods one day longer in 1910 than in 1904. There were 13 varieties with periods two days longer in 1904 than in 1910, and 12 varieties with periods two days longer in 1910 than in 1904; 13 varieties whose periods were three days longer in 1904 than in 1910, and 3 whose periods were three days longer in 1910 than in 1904; 3 varieties with periods four days longer in 1904 than in 1910, and only one with a period four days longer in 1910 than in 1904. Two other varieties exhibited still wider differences. Grandmother, which had a five-day period in 1910, had a ten-day period in 1904, a difference of five days, or a period twice as long in the year of late bloom as in the year of early bloom. The extreme of difference is seen in periods of Repka Malenka, which has a record of eight days in 1910 and of fourteen days in 1904, a period six days longer in the year of late bloom than in the year of abnormally early bloom.

Fluctuations in length of flowering periods from year to year are the rule rather than the exception and further illustrations will be given elsewhere. But the differences between periods in these two years, and the fact that for 50 varieties the periods were from one to six days longer in 1904 than in 1910, and that 29 other varieties had periods from one to four days longer in 1910 than in 1904, suggests the operation of influences aside from temperature and moisture and about which nothing definite is known.

VARIETAL FLOWERING PERIODS

For the different years the average varietal flowering period for all varieties blooming in the particular year, ranged from five to ten days. This average was five days in 1901 and 1915, six days in 1908 and 1912, seven days in each of six years, eight days in each of three years, nine days in 1903 and 1914, and ten days in 1907.

The extremes in length of blooming periods for individual varieties may be near together in one year and widely separated in another year; there is great variation in this. Thus in 1907, a year in which only 82 varieties bloomed, the minimum period of three days was represented by 2 varieties, the maximum period of seventeen days by 1 variety, and each number of days falling between three and seventeen was represented by 1 to 13 varieties; this largest number, 13, falling to the twelve-day period. The total number of periods, each differing from its neighbor by one day, was fifteen. At the other extreme, the year 1915 had the record of a concentration of 100 varieties into three blooming periods; 7 varieties had each a four-day period, 57 varieties had five-day periods, and 36 varieties had six-day periods. Next to 1915 in number of periods differing by one day, is the year 1902 with four periods ranging from five to eight days in length. The 87 varieties were distributed as follows: with five-day periods, 5 varieties; with six-day periods, 34 varieties; with seven-day periods, 31 varieties, and with eight-day periods, 17 varieties. Each of the years 1901 and 1912 concentrates the flowering record into five groups ranging from four to eight days. Other years range thru six, seven, eight, nine, ten, and eleven groups each, and then follow the maximum of fifteen groups in 1907, as already mentioned.

Concentration into few groups, or distribution into many groups, follows the full length of flowering period; that is, from the opening of the first flower on the earliest blooming variety to the fall of the petals on the latest blooming variety, with a regularity which, altho not perfect, approximates the expectation. The shortest blooming period was ten days in 1915, and in that year appeared the maximum of concentration: three groups of four, five, and six days, respectively. The longest blooming period of twenty-two days was recorded for the year 1907, in which year occurred the maximum distribution into fifteen groups with periods three to seventeen days in length.

Next below the maximum in length of flowering period come the two years 1903 and 1908 each with a period of twenty-one days. In the earlier year the 99 varieties flowering fall into ten groups with varietal periods ranging from five to fourteen days; in 1908 the 97 varieties fall into eleven groups with varietal periods ranging from three to sixteen days, but with no representatives for the nine-, eleven-,

and fourteen-day groups; 90 of the varieties were in the five groups with three to seven-day periods; the remaining seven were scattered in six groups of greater length.

The full flowering period in 1905 was nineteen days, that of 1909, eighteen days; in both years the number of groups was eleven, but in 1909 the longest period was one day longer than the longest period in 1905.

Distribution of varieties into groups according to length of blooming period is shown for each year in the accompanying table, together with the number of varieties blooming and the average varietal period for each year.

Table 2.—Distribution of Varietal Blooming Periods in Each Year

Year	Number of varieties blooming	Length of blooming period in days															Average varietal period, days
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
1901	76	...	39	19	11	6	1	...	...	...	...	...	...	...	...	...	4.83
1902	87	...	...	5	34	31	17	...	...	...	...	...	...	...	...	...	6.69
1903	99	...	...	7	10	5	26	4	12	13	16	2	4	...	...	...	9.20
1904	103	...	3	6	17	28	33	13	2	...	...	...	1	...	...	...	7.30
1905	104	3	1	5	10	11	25	21	21	3	3	1	...	...	...	...	8.23
1906	106	...	...	6	32	39	17	10	1	1	...	...	...	...	...	...	7.00
1907	82	2	1	1	8	5	10	6	12	11	13	4	4	3	1	1	9.93
1908	97	2	13	34	32	9	1	...	1	...	1	1	...	2	1	...	5.89
1909	100	1	3	20	21	12	25	11	3	2	1	...	1	...	...	...	7.02
1910	105	...	7	11	29	23	22	13	...	...	...	...	...	...	...	...	6.77
1911	103	...	4	11	18	12	34	17	7	...	...	...	...	...	...	...	7.35
1912	103	...	9	42	32	11	9	...	...	...	...	...	...	...	...	...	5.70
1913	102	...	1	15	25	12	11	12	21	5	...	...	...	...	...	...	7.58
1914	84	...	...	4	6	1	9	29	27	4	3	1	...	...	...	...	9.03
1915	100	...	7	57	36	...	...	...	...	...	...	...	...	...	...	...	5.29
1916	94	...	4	23	8	16	19	23	1	...	...	...	...	...	...	...	7.02

Amount of Bloom

While record of the amount of bloom has been kept under the five gradations—none, scant, moderate, full, and very full—as elsewhere explained, it is necessary to consider, from a practical standpoint, only three divisions; namely, no bloom, amount too small to suggest a crop of fruit, and sufficient to promise a crop. The amount of bloom is not open to exact determination and the record, at best, is only an estimate; but effort has been made to keep the basis of estimate as uniform as possible. It is believed that the record will be helpful in the summation of the characteristics of varieties, in segregating those with well-defined tendencies towards insufficient bloom from those having the opposite tendency, and in advancing studies that may be undertaken into the causes for blooming tendencies exhibited.

Observation of the blooming of apple trees year after year conveys a very definite impression of wide seasonal differences in behavior of

varieties and individuals, of very unequal response to exterior conditions observed and assumed to exert influence either as stimuli to increased activity or as agents operating to retard or diminish plant processes, and of the fact that factors governing performance are complex and dependent upon physiological changes that are difficult to understand or interpret rightly.

Amount of bloom is not determined at blooming time, as the buds are formed the preceding summer; they make small advance in the fall and may even make slight growth during the winter. They push and make rapid or slow development in the spring, according to the climatic conditions of the season, but whether the amount is large or small in a large measure must be controlled by conditions and surroundings of the trees during the formative period, nine or ten months preceding the opening of flowers in spring.

Classified into the three divisions—no bloom, not enough for a crop, and sufficient for a crop of fruit—the 1,696 records for the 106 varieties for sixteen years divide as follows: no bloom, 151; not enough to make a crop, 485; and enough to promise a crop, 1,060. Deficiency records constitute $37\frac{1}{2}$ percent of the total, leaving $62\frac{1}{2}$ percent to represent cases of sufficiency or excess of bloom.

The 151 records of failure to bloom are distributed in numbers ranging from 1 to 30 thruout fifteen years; only in the year 1906 did all varieties produce flowers. The larger number of failures, 30, occurred in 1901; in 1907 the number was 24; in 1914, 22; in 1916, 12; with numbers less than 10 in the other years.

Records of scant or insufficient bloom are much more numerous than those of no bloom, constituting, as they do, 28.6 percent of all records. Numbers of varieties appearing in this class, in the different years, range from 1 to 59 and are as irregular in distribution as are numbers in the class having no bloom.

In thirteen of the sixteen years, numbers of varieties in the scant bloom column are larger than in the no bloom column, but it does not follow that high numbers in the scant bloom column are always accompanied by low numbers in the no bloom column; thus in 1901 with the maximum of 30 in the no bloom column there are 33 in the scant bloom column, and in 1907 the respective numbers are 24 and 41. On the other hand, the two highest numbers of varieties in the scant bloom column are associated with low numbers in the no bloom column, as 59 scant bloom and 3 no bloom in 1911; 51 scant bloom and 2 no bloom in 1905. For the three years 1913-1915, the reverse is true; 1913 has 1 in the scant bloom column to 4 in the no bloom column; for 1914 the numbers are 14 and 22, and for 1915, 3 and 6 respectively.

The most satisfactory index of performance as to amount of bloom is found in the distribution of varieties between the two groups, insufficient or no bloom, and bloom sufficient for a crop.

Examining the record, it appears that 1913 was the year of maximum performance, for 101, or 95.28 percent, of the 106 varieties carried sufficient bloom. Next to this is 1915 with 97, or 91.51 percent, of the varieties having satisfactory production. At the other extreme are the years 1902 and 1907, each having only 41, or 38.68 percent, of the varieties in the group having sufficient bloom. The twelve other years have numbers of varieties in this same group ranging from 43 to 91, with percentages from 40.57 to 85.85.

It is, perhaps, worthy of note that only ninety-two records appear of varieties having exceptionally heavy bloom; these are distributed by years as follows: 30 varieties in 1914, 22 in 1915, 15 in 1902, 11 in 1904, 4 in each of the years 1901 and 1916, and 3 in each of the years 1903 and 1912. For the seven consecutive years 1905 to 1911, and for the year 1913—eight years in all—there are no varieties represented in the enumeration of cases of very heavy bloom. The varieties that do have place among those having very full bloom in one or more years number 58; of these 32 appear in the list but once, 21 appear twice, 3 appear three times, 1 four, and another five times. There are three cases in which the years of extra heavy bloom were consecutive and all for the years 1914 and 1915; the varieties are Pointed Pipka, Red Aport and Borsdorfer, the latter, eleven years before was credited with a third year of heavy bloom. There are also twelve cases involving 9 varieties in which years of very heavy bloom were separated by only one year, and that year had full bloom in one case, moderate bloom in seven cases, scant bloom in three cases, and none in one case.

The relation of very heavy bloom to bloom in preceding and following years has been examined and from the results it may be stated that in four cases where heavy bloom occurred in the first year of record, the performance of the preceding year was unknown; of the eighty-eight remaining records of the next preceding years, sixty-two, or 70.45 percent, had either full or moderate bloom (enough to promise a crop), while twenty-six, or 29.55 percent, recorded scant bloom or none. Following heavy bloom there were four years in which heavy bloom occurred in the last year of record with no record for the following year. The eighty-eight records of following years divide as follows: sufficient bloom for a crop in fifty-seven, or 64.77 percent, and insufficient or no bloom in thirty-one, or 35.23 percent.

For the twenty-one varieties, each appearing twice in the list of those recording heavy bloom, there are two cases in which the years of heavy bloom were consecutive, five cases in which there was alternation, with sufficient bloom in the intervening year, and fourteen cases in which the years of very heavy bloom were separated by eight to twelve years.

The three varieties each recorded as having heavy bloom in three years were Borsdorfer, Hibernal, and Willow. Borsdorfer had the highest record of any variety, for in not one of the sixteen years was there a deficiency in bloom; the record of this variety began with full bloom in 1901, extra heavy bloom in 1902 followed by three years of full bloom, a year of moderate bloom, then full bloom, again followed by a year of moderate bloom, then five consecutive years of full bloom followed by very heavy bloom in 1914 and 1915, ending with full bloom in 1916. Hibernal, while having very full bloom in 1902, 1904, and 1915, and sufficient for a crop in four other years, had no bloom in 1901, 1907, and 1914, and bloom insufficient for a crop in 1903, 1905, 1912, and 1916. A summary for this variety shows nine years of sufficient bloom and seven years of deficient bloom.

Willow began with very full bloom in 1901 and duplicated the performance in 1903, with a year between of scant bloom; it had full bloom in 1904 and of the following ten years, six had each enough for a crop and four less than enough, then came a year of very full bloom in 1915 followed by a deficiency in 1916; or, for the sixteen years, ten had enough bloom and six had deficiencies altho in no year was there entire absence of bloom.

The variety recorded as having very full bloom in four years was Oldenburg; the years of very full bloom were 1902, 1904, 1914, and 1916; between each of these pairs was a year of moderate bloom. The record began with scant bloom in 1901, then for the years 1905 to 1913 inclusive were six years of bloom sufficient for a crop, two years with insufficient bloom, and one year with no bloom—a record for the sixteen years of twelve years in which the bloom was good and four in which it was poor.

Borovinka reached the maximum with a record of five years of very full bloom. These years were 1902 and 1904, preceded, separated, and followed by years of scant bloom; 1912, preceded by a year of scant bloom and followed by a year of moderate bloom; and 1914 and 1916 with a year of no bloom between. The years 1906 to 1911 were represented by four years of bloom sufficient for a crop, one with insufficient and one with no bloom. Thus for the sixteen years, ten had sufficient bloom and six were deficient in bloom.

There are wide differences in varieties with regard to their blooming tendencies. Some varieties are inclined to produce sufficient bloom nearly every year while others rarely attain satisfactory production. Borsdorfer, as already mentioned, stood alone with record of sufficient bloom in each of the sixteen years. Then there were five varieties—namely, Arabian, Berry, Osimoe, Rome, and Zuzoff—each with deficiency in only one year, and six varieties—Arkansas, Borsdorf, Grandmother, Hargrove, Twenty Ounce, and Yellow Siberian Crab—

each with two of the sixteen years recorded as deficient in bloom. In another group of eleven varieties including Fameuse, Golden Ball, Roe's Tolman, Wolf River, and Wythe, each variety divided equally between years of sufficient bloom and years of deficiency. In still another group of twenty-two varieties each had from nine to fourteen years of deficiency, with two to seven years of sufficient bloom; among these were Huntsman, Jefferis, and Yellow Sweet, each with eleven lean years and five full years; Blackwood, Bogdanoff, Red Aport, and three others stood ten poor to six good. Most persistently unproductive of bloom were Peach and Rambank Gasser, each with record of fourteen years of deficient or no bloom and only two years with enough bloom to promise a crop.

It is possible to pick out, here and there in the record, instances of the alternation of full or heavy with light or no bloom, but occurrence of these instances is extremely irregular and much less common than the occurrence of three to five and even six consecutive years characterized by the same degree of bloom, either moderate or full or scant.

In this fact is seen evidence of the inequality of response by different varieties to the same attendant conditions. Thus for the four years 1909 to 1912, Borsdorf and Borsdorfer bloomed full in each of the years, while Fameuse had scant bloom in the first three years and moderate bloom in the last, Garden scant bloom in the first three years and moderate bloom in the last, Jefferis and Kruder scant bloom in all four years, and so they vary thruout the list. Each variety appears to follow a course of its own. Individuality stands out strongly and there appears no single agency nor group of agencies that operates on more than very restricted lists of varieties for limited periods, to govern performance in flower production.

Distribution of varieties in regard to amount of bloom in the different years is given in Table 3. Arranging the same records to bring the varieties into two groups on the basis of deficient or no bloom, and sufficient for a crop, and adding the percentages in each group for each year, the numbers of varieties distribute as shown in Table 4.

For the sixteen years the average percentage of varieties having bloom sufficient for a crop was 62.5 and there was equal division of the years, eight falling below the average and eight ranging above, but with no regular order nor alternation. The years falling below average were 1901, 1902, 1905, 1907, 1908, 1909, 1911, and 1912; those above average were 1903, 1904, 1906, 1910, 1913, 1914, 1915, and 1916.

Effort has been made to trace a relationship between the amount of bloom in any given year and conditions of temperature and moisture prevailing during the period of bud formation—that is to say, during the months of June, July, and August of the preceding year—

TABLE 3.—DISTRIBUTION OF VARIETIES AS REGARDS AMOUNT OF BLOOM FOR EACH YEAR

Years	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	Total record
0. No bloom	30	19	7	3	2	0	24	9	6	1	3	3	4	22	6	12	151
1. Scant bloom	33	46	27	12	51	24	41	33	44	37	59	42	1	14	3	18	485
2. Moderate bloom	16	4	49	29	29	46	37	37	33	21	26	34	47	29	47	52	536
3. Full bloom	23	22	20	51	24	36	4	27	23	47	18	24	54	11	28	20	432
4. Very full bloom	4	15	3	11	0	0	0	0	0	0	0	3	0	30	22	4	92

Grand total, 1,696 records.

TABLE 4.—DISTRIBUTION OF VARIETIES INTO TWO GROUPS: DEFICIENT BLOOM AND SUFFICIENT FOR A CROP, WITH PERCENTAGES

Year	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916
None or Deficient Bloom (0-1)																
No. of varieties	63	65	34	15	53	24	65	42	50	38	62	45	5	36	9	30
Percentage	59.43	61.32	32.08	14.15	50.00	22.64	61.32	39.62	47.17	35.85	58.49	42.45	4.72	33.93	8.49	28.30
Sufficient Bloom (2, 3, 4)																
No. of varieties	43	41	72	91	53	82	41	64	56	68	44	61	101	70	97	76
Percentage	40.57	38.68	67.92	85.85	50.00	77.36	38.68	60.38	52.83	64.15	41.51	57.55	95.28	66.04	91.51	71.70

but the irregularities found were such as to render doubtful the existence of any definite relation.

The summer months of 1912, preceding the year with the maximum percentage (95.28) of varieties having sufficient bloom (1913), had a mean monthly temperature of 71° and rainfall of 7.63 inches. Next to 1913 was 1915, with 91.51 percent of the varieties having sufficient bloom. For the summer of the preceding year, the mean monthly temperature was 78.2°, the highest of any year, and the rainfall 6.49 inches.

Record of these years suggests the possibility of high percentages of varieties having abundant bloom in years following high summer temperatures and low rainfall; but other years with preceding summer temperatures almost as high and with rainfall higher, but still below normal, do not exhibit the same high percentages of varieties with ample bloom. Thus 1911 with only 41.51 percent of the varieties having sufficient bloom, had, in the preceding summer, a mean monthly temperature of 71.8° and a rainfall of 8.37 inches; 1907, with 38.68 percent of the varieties with bloom enough for a crop, had, for the preceding summer period, 72.5° as the mean monthly temperature and a rainfall of 9.81 inches.

Perhaps the irregularities of the relation between the amount of bloom and the weather conditions for the preceding summers are rendered most evident by grouping and comparing the highest and lowest percentages of varieties having sufficient bloom. Thus the average percentage of varieties having ample bloom in the years 1904, 1913, and 1915 (90.88 percent) may represent the highest. The average mean monthly temperature for the preceding summers was 73.3° and the average rainfall for the same periods, 8.05 inches. With this group compare the years 1901, 1902, and 1907, the three years having the lowest percentages of varieties with sufficient bloom, and which have an average of 39.31 percent. Mean monthly temperature for preceding summers averaged 73.9°, with the average rainfall 11.31 inches.

While it appears that the percentage of varieties having enough bloom for a crop was nearly $2\frac{1}{3}$ times greater for the high than for the low group, the average temperature for the summers preceding the years of high percentages of varieties having enough bloom was less by 0.6° than for the same periods preceding percentages in the low years, and the rainfall for summers preceding high percentages was less by 3.26 inches than for summers preceding low percentages.

Comparison in the same way may also be made on the basis of highest and lowest rainfall during preceding summers. Thus the average rainfall for the summer months of 1902, 1907, and 1915, the years of greatest rainfall, was 18.71 inches; and the average percentage of varieties with sufficient bloom in the next following years,

1903, 1908, and 1916, was 66⅔ percent. The years 1909, 1912, and 1914, following the years of lowest rainfall (an average of 5.28 inches for the summer months) show an average of only 58.81 percent of the varieties with sufficient bloom. From these contrasting periods it would appear that the highest bloom percentages follow years of highest rainfall.

Again comparison may be made on the basis of mean temperatures for preceding summers. The three years having highest summer temperatures were 1901, 1913, and 1914, with an average monthly mean of 76.5°; the average of varieties having sufficient bloom in the next following years was 65.41 percent. Years having lowest summer temperatures were 1903, 1904, and 1915, with an average monthly mean for the period of 70.6°; for the next succeeding years, 1904, 1905, and 1906, the average of varieties with sufficient bloom was 69.18 percent. Here the years of high summer temperatures were followed by lower percentages of varieties having sufficient bloom than any recorded for years following low summer temperatures. These comparisons of high and low temperatures make it appear that, on the basis of percentages of trees having sufficient bloom, high percentages follow years having slightly lower temperatures and appreciably lower rainfall than the years preceding the low percentage years; that on the basis of rainfall, high percentages of varieties with sufficient bloom follow years of highest rainfall; and that on the basis of temperature, the high percentages follow the lowest temperatures.

Several other combinations have been examined, but no importance attaches to any of them. Correlation between percentages of bloom and temperatures and rainfall of preceding years cannot be established for the reason that temperature and rainfall are only two of a long array of climatic factors, all of which operate to influence bloom performance.

Temperature and rainfall may be the most important agencies affecting amount of bloom, but taken separately they cannot lead to correct interpretation of observed results because other and possibly equally important factors are left out. Computations from incomplete data only serve to confuse; they do not aid in understanding observed phenomena and hence accomplish no good purpose.

That the wide variations in numbers of varieties producing bloom and the equally wide variations in amount of bloom in different years, result from definite causes is a warranted assumption, but determination of these causes is impossible in the absence of complete data, and even with full data would be difficult because of the complex nature of the problem. Like any other problem involving the physiological processes of plants, the factors that influence results are very numerous; these factors interact among themselves, they are difficult to

isolate; and to correctly associate any one of them with observed phenomena is possible only thru close and prolonged study.

Amount of Bloom and Distribution of Varieties Into Time-Groups

An impression, acquired from observations and unclassified notes, that concentration of the flowering of varieties into a few time-groups occurred in years of heavy bloom, and that wide distribution into many groups was characteristic of years of light bloom, is not fully supported by the tabulated records of all years. It is true that 1907, the year of widest distribution, when there were fifteen groups ranging from three to seventeen days, was one of two years having the minimum amount of bloom. In 1907 only 41, or 38.68 percent, of the 106 varieties had bloom in quantity sufficient to promise a crop; 37 of the varieties were recorded as having moderate bloom and 4 as having full bloom; 21 varieties had no bloom and 44 had each a few scattering flowers, not enough, however, to suggest a crop of fruit. The year of maximum concentration, when the varieties having bloom enough for a crop were gathered into three groups of four-, five-, and six-day periods, was 1915, a year standing next below the maximum in amount of bloom. In this year there were 97 varieties, or 91.51 percent of the total, with bloom sufficient for a crop; 47 varieties had moderate bloom, 50 bloomed full and 22 of these were very full.

These years of minimum and near-maximum bloom support the impression of a relationship between amount of bloom and time distribution, but this suggested relationship is rendered doubtful by the bloom performance of other years. For the year of maximum bloom, 1913, when 95.28 percent of the varieties carried bloom enough for a crop, there was distribution into eight groups ranging from four to eleven days. In the year 1902 which, in company with the year 1907, records the lowest percentage of bloom, only 38.68 percent, there was concentration into four groups ranging from five to eight days. Next above the minimum in amount of bloom was the year 1901, with a percentage of 40.57 and with five groups ranging from four to eight days. The three years 1905, 1908, and 1909, each with a distribution of varieties in eleven groups, have percentages of varieties blooming of 50, 60.38, and 52.83 respectively. Without going further into detail it appears that for selected pairs of years a rather definite relation may be shown between the number of varieties blooming and the distribution of the varieties into greater or less numbers of time-groups, but when the aggregate of records is considered no constant relation is apparent.

TEMPERATURE AND DISTRIBUTION OF BLOOM

Temperature for the duration of the blooming period is, without doubt, an important factor in influencing distribution of varieties into groups representing flowering periods of different lengths. Comparing the record of flowering periods and distribution with the mean daily temperatures for the respective years, it appears that in the main, length of period and distribution fluctuate with mean daily temperatures. Thus the year 1915, with the shortest recorded full flowering period of ten days and concentration of the 100 varieties into four-, five-, and six-day groups, had a mean daily temperature for the period April 23 to May 2 of 67.1°; while, the year 1907, with a flowering period of twenty-two days and a distribution of the 82 varieties into fifteen time-groups ranging in length from three to seventeen days, had a mean daily temperature for the period April 20 to May 11 of 48.1°. Other years exhibit a somewhat similar relation, but there are sufficient irregularities to indicate that factors other than temperature frequently operate to modify both length of blooming period and range of distribution. For example, the year 1910, with a full flowering period of eighteen days and a distribution of varietal periods into six groups of four to nine days each, had a mean daily temperature for the period April 2 to April 19 of 53.4   while for the year 1914, with a full period of fifteen days and the varietal periods distributed in nine groups of five to thirteen days each, the mean daily temperature from April 27 to May 11 was 61.5°.

A further indication of the operation of factors other than temperature is suggested in the fact that varietal flowering periods of three days are recorded only in the years 1905, 1907, 1908, and 1909, all of which had long full-flowering periods. The distribution of varieties into the maximum numbers of groups and mean daily temperatures for the respective flowering periods were as follows: 58.4°, 48.1°, 50.4°, and 55.6°.

Examination of the flowering record of all varieties arranged by years shows that wide variation in length of varietal blooming periods in different years is common to all, but the range varies for different varieties. There are 8 varieties each having three days as the minimum period; for these varieties the maxima range from eight to fifteen days. Next to this is a group of 63 varieties, each with a minimum period of four days and here the maxima range from eight to sixteen days. Then follows a group of 33 varieties each with a minimum of five days and maxima ranging from nine to seventeen days. Finally, of 2 varieties each having a six-day period as the minimum, one has a maximum period of eleven days, the other a maximum period of fifteen days.

Variation in length of flowering period is expected. Mean temperatures for particular periods vary greatly in different years, and

flowering periods should be long when temperatures are low and short when they are high.

While this relation between temperatures and length of flowering periods is apparent in a general way, there are many irregularities and such wide departures from the rule as to make it evident that important and complex factors other than temperature and atmospheric conditions at time of blooming, operate to modify the duration of flowering periods. To illustrate, the flowering periods of Domine and Fameuse for the year 1907 may be compared. The period for Domine was six days, that for Fameuse fourteen days; the mean daily temperature for the six-day period of Domine was 47.6°, that for the fourteen-day period of Fameuse 47.4°. It does not appear reasonable that a difference of 0.2° in mean daily temperature should be the sole cause of prolongation of one period to $2\frac{1}{3}$ times the length of the other.

A similar case appears in the record of flowering periods for Rome and Wolf River in 1903. The mean daily temperature for the Rome period of twelve days was 53.6°, and for the five-day period of Wolf River 53.4°. Another example is found in comparison of the records of Shockley and Tolman, also for the year 1903. Shockley had a flowering period of ten days, Tolman a flowering period of six days; the mean daily temperature for the Shockley period was 50.5°, that for the Tolman period 49.6°. Here the shorter period had a mean daily temperature less by 0.9° than that of the longer period. For the year 1908 these same varieties show a rather extreme difference; Shockley had a flowering period of six days while that of Tolman was sixteen days, but in this case temperature may be accepted as the chief cause of difference, for the mean daily temperature of the Shockley period was 57.6°, while that for the Tolman period was 47.1°, a difference of $10\frac{1}{2}$°.

INCONSTANCY OF RELATIVE LENGTHS OF VARIETAL BLOOMING PERIODS

With nearly all varieties there are marked irregularities in the alternation of long and short blooming periods and, further, there are conspicuous departures, from those relative lengths of periods of different varieties, that might be easily assumed to be constant; that is to say, where two varieties in any one year have blooming periods differing in length by several days, one perhaps twice as long as the other, it would not be unreasonable to suppose that the varieties in question would hold to an approximation of the difference in other or all seasons. As a matter of fact, the relative lengths of the periods in one season may be reversed in a succeeding season. Such occurrence indicates plainly that temperature and general atmospheric conditions, which are commonly regarded as the chief determiners of length of blooming periods, do not act equally on all varieties in all seasons, or

that varieties develop within themselves qualities that render them less susceptible to stimulation, or more resistant to adverse conditions in one season than in another. Records for Tolman and Whitney will serve to illustrate the fluctuations here referred to. The flowering period for Tolman in 1903, a year having a long average flowering period (9.2 days) for all varieties, was six days; while in 1908, when the average period for all varieties was short (5.94 days), the period recorded for Tolman was sixteen days. In contrast with this record Whitney, with an average flowering period for sixteen years of $7\frac{3}{4}$ days, had its flowering period lengthened to fourteen days in 1903 and contracted to five days in 1908. Records for these two varieties for the two years, placed side by side for ready comparison, appear as follows:

	1903	1908
Blooming period for Tolman	6 days	16 days
Blooming period for Whitney	14 days	5 days

Tolman did not bloom in 1907, so that the two varieties can be compared for only fifteen years. For the years other than the two given above, the flowering periods of the two varieties were as follows: they were equal in 1912, in five years Tolman had the longer periods by one to two days, and in seven years Whitney had the longer periods by one to five days. The trees compared were of the same age, grew but a few rods apart and received the same care each year.

To further illustrate irregularities in flowering periods, certain other varieties may be briefly mentioned. Ben Davis is recorded as having a range in length of periods of five days to thirteen days, distributed as follows: five-day periods in each of five years, six-day periods in each of four years, seven-day periods in each of two years, eight-day periods in each of two years, and thirteen-day periods in each of two years. The two thirteen-day periods are recorded for the years 1907, in which the average blooming period for all varieties was 9.93 days, and 1914, in which the average blooming period for all varieties was 9.03 days. The mean daily temperature for the blooming period in 1907 was 49.4°, in 1914 it was 60.4°; a difference of 11°, altho the blooming periods were the same. For the five years having each a five-day period, the mean daily temperatures for the blooming periods range from 47.4° in 1908 to 70.2° in 1913; an extreme difference of 22.8°.

The record for Domine shows equal flowering periods of six days for the years 1906 and 1907, with a difference of 14.3° between the mean daily temperatures of the periods for the two years. Similarly the years 1903 and 1904 had each an eight-day period with a difference between mean daily temperatures of 10°.

Variations in length of blooming period and relations to mean daily temperatures such as have been cited are of common occurrence in all

varieties, but are more strikingly in evidence in some varieties than in others.

The variations indicate clearly that there are more influences controlling length of blooming period than can be ascribed to spring weather conditions alone, and by their marked irregularity suggest that the individual rather than the variety must be the basis from which performance is considered. Trees of one variety growing together in a single row do not act alike; one starts earlier, pushes stronger, and completes its period of bloom in less time than does its neighbor. It is said of such a tree that it was in better condition than the other, had more vigor, and thus was enabled to outclass its neighbor. This is true, but when the question is asked as to why the tree was in better condition and possessed of greater vigor, the answer is not immediately forthcoming.

The two trees, Tolman and Whitney, had been neighbors for several years, subjected to identical conditions so far as is now apparent. It is necessary to go back several months or possibly years, investigate relative activity in the various life processes, determine the performance, and then possibly fail to find the existing cause or causes of the differences recorded. The tree of greater vigor may be constitutionally better than its neighbor, it may have had access to better food supply, it may have more completely recovered from a fruiting effort, it may not have been exhausted by fruit production the year previous while its less vigorous neighbor may have been, or it may have escaped a parasite that damaged its neighbor. Any of these or other possible causes, singly or in combination, may have operated to bring about the recorded difference, leaving no evidence of operation that is apparent at the time bloom record is made.

SUMMARY

Blooming marks what is perhaps the most critical period in the production of a fruit crop, and success or failure of the crop is, in a large measure, dependent upon spring weather conditions. Blooming records of 106 varieties, each having a record of ten to sixteen years, are considered for the sixteen-year period 1901-1916. Record for each variety for each year includes dates of first bloom, full bloom, and petals falling; also, an estimate of the amount of bloom.

1. Flowering periods in Illinois are extremely variable from year to year, but in general are shorter than flowering periods in Virginia, New York, Oregon, and in England.

2. For the sixteen years the full flowering period for all varieties has ranged from ten to twenty-two days, with an average of approximately sixteen days. The earliest date of an open flower was April 2; the latest date in the record of petals falling was May 21, placing the extremes for the sixteen years fifty days apart.

3. Early Ripe, Zuzoff, and Oldenburg, while shifting relative positions from year to year, hold place as the earliest bloomers more consistently than do other varieties. The latest blooming varieties were Repka Malenka and Wythe.

4. The blooming period in 1910 was a full month earlier than in other years because of abnormally high temperatures during the month of March.

5. Blooming periods for individual varieties have varied in length between three and seventeen days, while average periods, for all years, range from five to ten days. The average period for all varieties was five days in 1901 and 1915; six days in each of two years, seven days in each of six years, eight days in each of three years, nine days in 1903 and 1914, and ten days in 1907.

6. Extremes in length of blooming periods for individual varieties may be near together in one year and widely separated in another year. Thus in 1907 the shortest period was three days, the longest seventeen days, and each number of days between three and seventeen was represented by 1 to 13 varieties, giving fifteen time-groups for that year, while in 1915 there was concentration into three groups of four-, five-, and six-day periods.

7. Amount of bloom was estimated for each variety for each year and from this record it appears that 68 varieties aggregate 151 records of no bloom. For the full list of varieties there are 485 records of bloom insufficient for a crop, and 1,060 records of a sufficient amount or an excess of bloom. In other words, 62½ percent of the records indicate enough bloom and 37½ percent represent deficiencies. Records of very full or excess bloom aggregate only 92, or 5.42 percent of all

records, and these are distributed in eight of the sixteen years. Effort to establish a relationship between amount of bloom and temperature and moisture conditions prevailing during the period of bud formation in preceding summers developed such irregularities as to render the existence of any definite relation doubtful.

8. In a general way mean temperatures during blooming periods influence the length of periods and the distribution of varieties into few or many time-groups, but there are enough irregularities to indicate plainly that there are influences other than temperature that operate to modify both length of period and range of distribution of varieties.
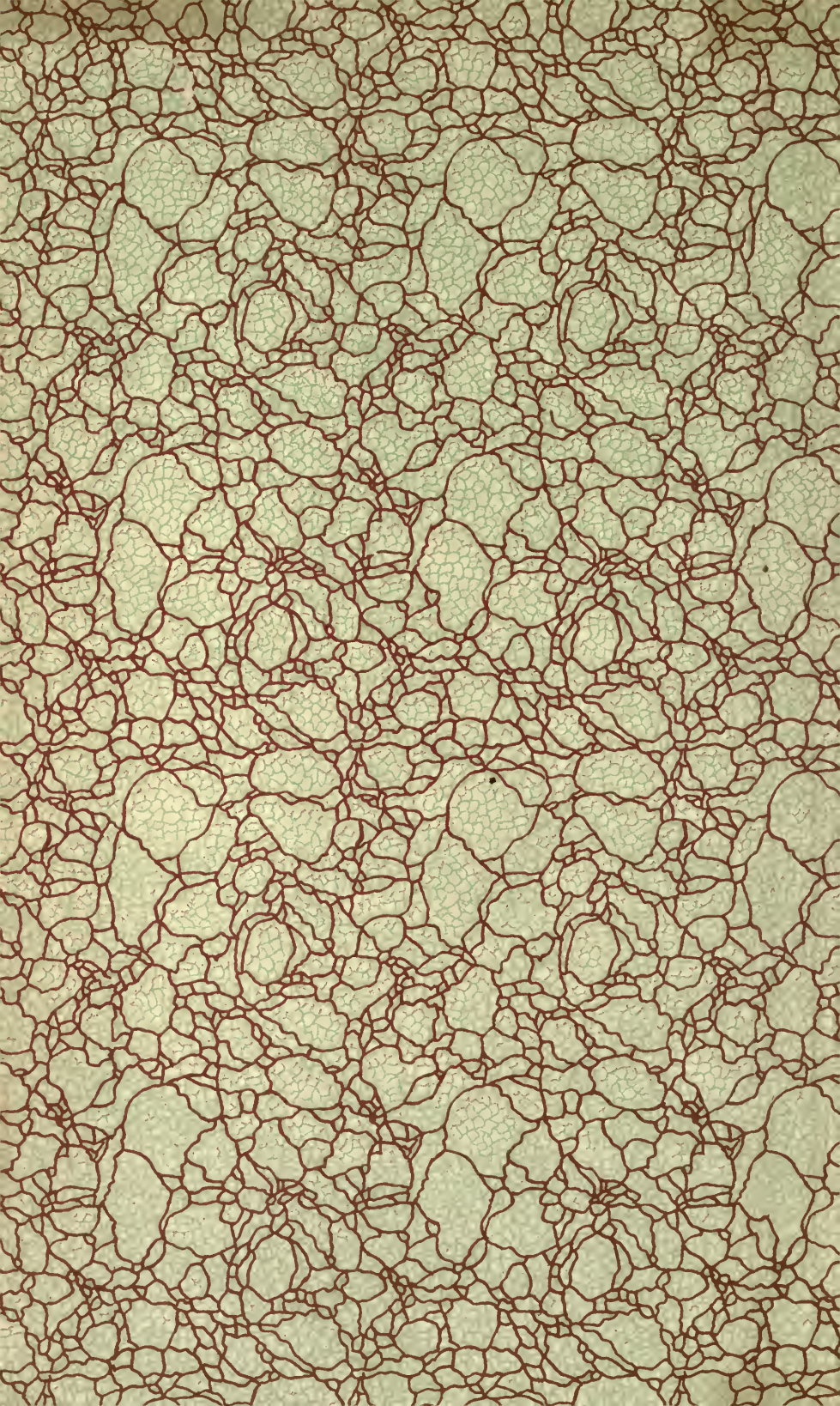
9. Inconstancy in relative lengths of blooming periods is characteristic of all varieties. Two varieties, one having a blooming period twice as long as the other in a particular year, may exactly reverse their relative positions in a succeeding year.

10. Influences affecting the blooming periods of apple trees are extremely complex. Climatic conditions are important, but their influence is modified by physiological characteristics which are obscure, difficult to isolate, and which operate to make it impossible to interpret the vagaries of 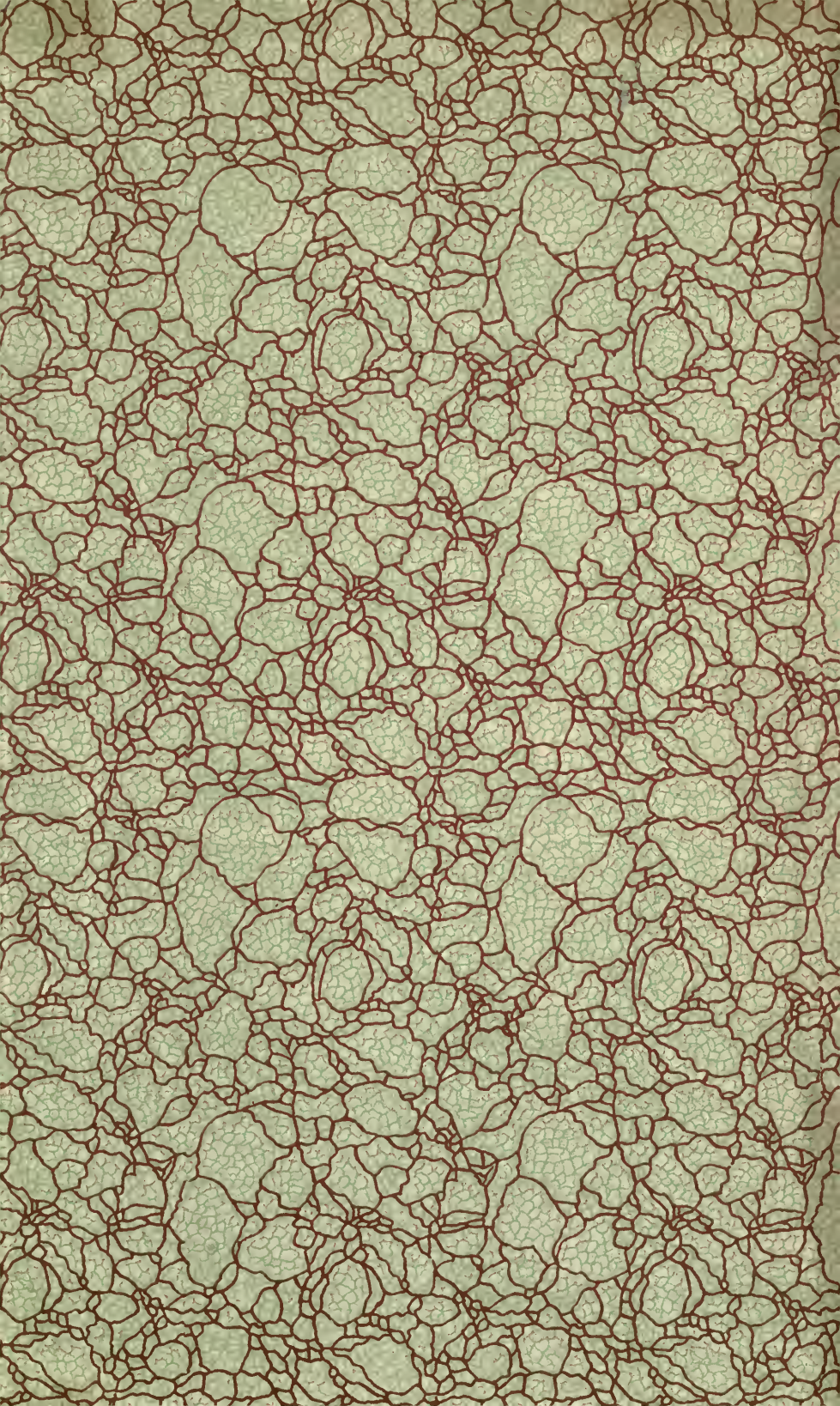blooming phenomena from the bloom record alone.